How, Thanks to a Decision Support System Called “Profiling,” a Forest Manager Saved His Forest But Lost His Job

John E. Lundquist

Efficient and effective forest disease management relies on good research, yet forest managers are sometimes slow at adapting and implementing research discoveries. Meaningful research on management issues relies on an understanding of the difficulties of management, yet research discoveries often are remotely applicable to day-to-day management decisions. This communications gap may constrain the science and application of forest disease management. A fictional case study examines the incongruence between a new-economy manager and an old-economy corporate office when a decision support system called “profiling” is used to solve an ecological problem in an economic context. It illustrates the risks managers take when implementing new technologies—in this case, using information technology in a forest business when a root disease limits timber production. In the story that follows, our narrator is attending a guest lecture.

Keywords: communication; decision science; industry

Only a handful of people showed up to listen to Professor Edwin L. Seaworth speak on integrating information technology (IT) with forest pathology research. Why not? IT seems to have been integrated with everything else. Seaworth seemed like a funny old man, with a little white beard and dressed in a gray suit adorned with a bow tie. No one wears suits anymore, and no one wears bow ties. No wonder he studied dead trees! He had just embarked on a case study when I took my seat.

Jim Baxter was employed by Shiresheep Forests—a timber production company that owned five forests in Colorado and New Mexico. Baxter managed one of these forests, a 365-stand, 25,000-acre forested watershed near Durango. Goatfoot Forest produced sawtimber. The corporate office in Denver practiced a decentralized organizational control and treated Goatfoot Forest as a profit center (Atkinson et al. 1997), which enabled Baxter to largely control decisionmaking about costs and sales. Corporate was interested only in the bottom line.

Baxter set his operational goals on the basis of annual tree growth—volume increment. Field crews inventoried each stand every year, and volume increment measurements in any one year were used to establish harvest limits for the following year; no larger volume was harvested in one year than grew the preceding year. Production efficiency was based on volume of trees harvested.

Baxter replaced R.J. Schifter, who had managed Goatfoot Forest for 40 years. Schifter liked to collect data and had designed the current field inventory system. Schifter seemed not to have used the information, however, and 25 years’ worth of data was stored on paper in fireproof vaults.

Amazing. Data have no value unless they are used.

When Baxter took over from Schifter, he had these data entered into the corporate database, which was linked to all five forests. He realized that Schifter’s data could be used to calculate standards for performance criteria—to determine trends in annual growth and harvest.

Unit stump price varied. In 1991, when Baxter took his position, prices were $150 per m³, with a total sales of $15,300,000, based on an annual in-
crement of 102,000 m³ in 1990. Corporate was keen on segmental analyses as a basis of comparing efficiency among the five forests. They used a variety of profitability indices, but the CEO was particularly fond of using the Dupont method to calculate return on investment (ROI).

According to Corporate’s calculations, increment began falling soon after Baxter arrived. With the exception of 1995, ROI showed a steady drop after 1992 to a low in 1996. This corresponded to a 66 percent reduction in net income from $2,941,000 in 1992 to $1,002,000 in 1995. Corporate’s segment analysis showed Goatfoot Forest to be the least profitable operation beginning in 1994, and Baxter knew he had to do something to improve profitability.

Baxter occasionally toured his forest, and one day he noticed several trees that had recently died. The more he looked, the more dead trees he found. Was this the limiting factor for volume increment? He approached the people who had worked in this forest for many years. These old-timers agreed that, in the past few years, mortality seemed a little worse. Some had noticed a white, paintlike growth under the bark of some dead trees. Baxter contacted the state pest specialist, Simon Jacobs.

The white growth was *Armillaria ostoyae*, a pathogen that causes a root disease. Jacobs explained that this disease usually occurred in stressed stands and said that silvicultural maintenance could relieve the stress and reduce incidence of the disease. He mentioned a publication by Kolb et al. (1994), who concluded there were many definitions of stand health. But in practice, Jacobs said, most foresters use gut feel.

Baxter asked the old-timers which stands were healthy. The old-timers came up with a list of 50 stands that all agreed were healthy. Baxter examined this list for common characteristics but just got frustrated.

The old-timers had tacit (unarticulated) knowledge. Baxter needed to convert this tacit knowledge to “collective knowledge.” By involving the old-timers and objectifying and harnessing (Mascitelli 2000) their tacit and collective knowledge, Baxter had created the basis of an organizational knowledge. Furthermore, by encouraging the old-timers to work together in identifying healthy stands, he created a “community of practice” in which new knowledge was created through collaborative interactions (Wenger and Snyder 2000). Baxter had become an information manager.

Baxter visited J.E. Larson at the Forest Service Research Station in Fort Collins. Using Larson’s computer, Baxter downloaded the appropriate data files—65 variables for each stand, including such attributes as stem density,
Larson was enabling Baxter to identify relevant variables in the database by data mining. The old rule was that only experienced practitioners could make complex decisions, but decision tree methods like the Classification and Regression Tree (CART), expert systems, and neural networks have enabled less experienced managers to make expert decisions. I recalled that decision tree analyses had been used in a few studies of pathogens (Byler et al. 1990; Baker 1993). Expert systems have also been applied to forest pests, mostly to aid in field diagnostics (Vakeva and Saarenmaa 1992).

But when Baxter said he wanted more discriminating power than just healthy or not healthy, Larson suggested a method called “profiling.” It would enable Baxter not only to predict whether each stand was healthy, but also to quantify how healthy and help prioritize work schedules by ranking stands needing silvicultural maintenance. Larson explained that profiling uses multiple characteristics derived from inventory data and defines the condition of an individual stand as a function of its suitability for achieving a specified management objective. The current state of a stand is measured relative to a suitable target condition in two-dimensional multidimensional scaling space. With this technique, Larson explained, target conditions are modeled using sets of stands selected by experts that represent examples of optimal conditions for selected management objectives.

He gave an example of a forest of 13 stands (fig. 2). The “core range of variability” (CRV) represents the threshold of suitability; all stands that fall within its bounds are suitable. If health is the objective, then these stands are healthy. Stands A and B, in contrast, are unhealthy, and the distance they lie from the edge of the CRV is a measure of how unhealthy. Profiles of multiple variables associated with each stand determine where points fall. When values for these variables change, positions of points characterized by those profiles change. The objective of a manager would be to develop a prescription based on an assessment of the current profile values that would move the outliers into the CRV. Larson explained the more technical details, like how the threshold levels of suitability were established using a kernel density estimation, and referred Baxter to a paper that had recently been published (Lundquist and Beatty 1999).

Profiling seemed fairly abstract. But then again, forest health is pretty abstract. Why should I expect a quantification of health to be any different?

Larson used the profiling method to model Goatfoot Forest (fig. 3) and found a large variety of levels of health. The empty circles represent the stands selected by the old-timers, and the full circles are those that were not yet assessed for health. The contours represented different definitions of health, and each dot represented a stand. Each stand has spatial coordinates, and stand health has a spatial distribution. To illustrate this, Larson linked the profiling results to a GIS. Different contour lines corresponded to different levels of stringency in defining health. Baxter would have to decide how stringent his definition of health should be.

Until recently, I knew, GIS in forestry had been used mostly for spatial inventories, not decision support systems. By integrating profiling into a GIS framework, Larson created a decision tool that certainly goes beyond simple maps. So now GIS is a decision support system generator (Martin et al. 1999).
Profiling, Larson said, offered a way to quantify stand health and help decide which stands to treat and in what order. Furthermore, by comparing current profiles of unhealthy stands with healthy stands, Baxter could determine which variables to silviculturally manipulate (table 1).

Baxter could see that profiling required many steps, including running several statistical programs. In addition, it was fairly abstract, and Baxter knew he would not be comfortable making decisions based on abstractions.

But Larson was prepared for this. After all, what good is this knowledge-generating system if it did not create knowledge that would be used? He brought up another image on the computer screen. “This user interface,” he said, “should enable you or your associates to do your own assessments and develop your own silvicultural health maintenance prescriptions.” Larson was willing to give Baxter a copy of the profiling analytics that were integrated into a user interface if Baxter would operationally test it. Baxter gladly agreed.

Larson created a GIS representation of Goatfoot Forest, color coded on the basis of relative health. When a pointer was moved to a specific stand, profile values for that stand would appear in a table, and a dot representing the stand would be highlighted in a two-dimensional target. As the operator changed the position of the target, the position of the point representing that stand would change. The objective of the operator would be to change the profile values in a way that the point would come to rest within the targeted CRV.

I recalled an instructor who said that cutting-edge decision support systems could be intimidating. Managers do not necessarily seek them, or use them when they have them.

Back in Durango, Baxter used the profiling program to determine stand harvest priorities based on level of health and spatial distribution of stands. Using the computer interface, he developed his silvicultural prescriptions by changing the profile variable values and seeing how these changes would move the dots in two-dimensional space. He implemented silvicultural actions based on profiling in 1996 and again in 1997. These activities increased health maintenance costs considerably, from $4,000 in 1995 to $25,000 in 1996 and $24,000 in 1997, but Baxter knew that forest health was increasing and the risk of future disease impacts was decreasing.

Baxter contacted managers facing similar forest health problems. By using Larson’s model as a focus, he developed an intraorganizational network of managers who discussed specific issues by e-mail and on a bulletin board. By creating a virtual team (Saunders 2000), Baxter created a network-based knowledge management system that could supplement the repository knowledge system in the corporate database (Alavi 2000). Technically, this amounted to an organizational restructuring by diminishing boundary distinctions among various individual forests of the Shiresheep company. By using IT to emphasize management of forest health in addition to the production of timber volume, Baxter had expanded the managerial goals of his responsibility center. He was managing information as well as timber production. The implementation of IT caused changes in processes at various organizational levels (Robey and Boudreau 2000).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Current value</th>
<th>Target value</th>
<th>Prescription</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem density</td>
<td>437</td>
<td>150–250</td>
<td>200</td>
</tr>
<tr>
<td>Basal area</td>
<td>30</td>
<td>25–35</td>
<td></td>
</tr>
<tr>
<td>Snag frequency</td>
<td>28</td>
<td>15–20</td>
<td>17</td>
</tr>
<tr>
<td>Log frequency</td>
<td>214</td>
<td>300–400</td>
<td>350</td>
</tr>
<tr>
<td>Age</td>
<td>140</td>
<td>136–210</td>
<td></td>
</tr>
<tr>
<td>QMD</td>
<td>20</td>
<td>15–30</td>
<td></td>
</tr>
<tr>
<td>Mean height</td>
<td>76</td>
<td>60–90</td>
<td></td>
</tr>
<tr>
<td>Growth increment</td>
<td>7.63</td>
<td>3.0–8.0</td>
<td></td>
</tr>
<tr>
<td>Species diversity</td>
<td>1.3</td>
<td>1.5–2.1</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Example of how variables for a given stand would be compared to target values to develop silvicultural prescriptions.

What a great example of using IT in managing a forest disease! The profiling decision support system had led to a radical change in the management procedures used on Goatfoot. Baxter had launched a virtual team (Saunders 2000) that found its cohesiveness in the common problem of forest health. And the IT affected several levels of the company: individual managers, forests, interorganizational, and organizational. Baxter had made wise management and leadership decisions. This reminded me a lot of that reading on radical changes by Segars and Dean (2000). The authors would say Baxter had taken the explorer role when his forest had a discovery capability and need, he had created organizational resolve as a gatekeeper by setting a clear direction about how decisions were to be made, he advocated the proper resources to address organizational goals, he facilitated those goals by articulating and communicating the value of profiling, and he applied the organizational knowledge derived from earlier lessons to application.

Baxter was fired in 1998.

Whoa! The guy was fired!

Despite the increases in volume increment, allowable harvest, total sales, and stand health, Baxter got the axe. The values of his changes would materialize only in the future. Corporate assessed the impacts of management operations by ROI and, benchmarked off the other Shiresheep forests, ROI for Goatfoot reached an all-time low in 1997.

The first decision of Baxter’s replacement was to reduce the forest health maintenance costs. As a consequence, ROI began a steady climb, and Corporate was relieved. The new man had obviously turned things around, and in 2000 he was awarded the Best Manager plaque and promoted to general manager for the company.
I was shocked. Beyond any rational argument, Baxter had brought his forest into the new economy and had set the stage for a radical change at Shiresheep Forests! I raised my hand. “What happened?” I asked. “I mean, Baxter did all the right things. He should have been recognized as the great innovator! Instead, his successor got all the credit and worse—set the forest up for another stress episode.” Seaworth smiled.

Baxter did all the right things except two. First, as Segars and Dean (2000) would put it, he was not an effective scorekeeper and did not develop the right metrics. His new-economy innovations did not include new-economy performance measures. Although the value of implementing IT on various levels of an organization seem intuitive, measuring these impacts is surprisingly difficult. Traditional-economy metrics still dominate. The corporate office was guided not by an objective measure but rather by indices that measure profit. Metrics used to evaluate performance in the old economy may not be useful for evaluating performance in the new economy.

Barua and Mukhopadhyay (2000) present a fairly detailed description of the problems with measuring impacts of IT in organizations. According to these authors, the problems arise largely because IT impacts are mostly indirect and diffuse among activities. It is hard to separate the effects of IT from other causes of changes, such as business strategies, processes, and incentive systems.Todd and Benbasat (2000) present a model suggesting that the performance effectiveness of decision support systems has multiple independent and dependent variables and that IT input does not necessarily equal productivity output. Barua and Mukhopadhyay (2000) present this as the production economic-based model and suggest that a more complex version based on processes might be more useful in measuring impact of IT on business performance. Process models link intermediate variables that are more directly affected by IT as intermediate variables.

The second factor that worked against Baxter was time. Sampler (1998, 2000) mentions that a time lag commonly occurs between the creation of a technological tool and use of this tool by managers. In this case, implementing health maintenance required increasing operating expenses by 525 percent. Business operates at an increasingly rapid pace; forest ecosystems change very slowly. Consequently, health maintenance was mostly an investment in future volume increment, and the value arising from these investments would not be realized until the biological system responded. The time scale of response is not necessarily the same as the time scale of financial balance sheets used by Corporate. Managerial performance and financial performance are not always measured on the same time scale.

The forest responded, but not soon enough to save Baxter’s job. Without making this investment, the stands would probably continue to lose health and his successor would not have been named Best Manager.

The time problem was easy to understand, but to say that measuring IT impacts “is surprisingly difficult” and the impacts “are mostly indirect and diffuse among other activities” was just insufficient. “But,” I asked, “what could Baxter have done to save his situation?” Seaworth pondered this question for several seconds before answering.

There are probably many answers to this question, but Baxter would have probably still lost his job. Let me explain.

Much has been written about improving the use of science in ecosystem management decisionmaking and about the gaps that exist between research scientists and managers (Walters 1998; Mills and Clark 2001). Much has also said about inefficiencies within organizations arising from inadequate or inappropriate governance structure and corporate organization. Profiling was an appropriate and useful product for making decisions about managing the disease that was damaging Baxter’s forest, and Baxter made good and appropriate use of this research product. His good management decision addressed the research and management issue but not the governance issue.

Decisionmaking is not necessarily a linear process, where research produces a tool, the tool is used by managers, and corporation profits increase. A more adequate model might look like a network of processes that are directly and indirectly linked in a tangled mess: Causes and effects are unclear. Disease is an ecological phenomenon acting within a dynamic heterogeneous forest ecosystem. Compared with a factory producing goods, a natural ecosystem is very complex, and managing it is more difficult.

Baxter needed to give his bosses a sense of this complexity, a clear vision of his goals, his best assessment of the risks of success and failure, and better yet, predictions of what to expect by implementing profiling as a disease management tool. In short, Baxter was ineffective at communicating the promise of this decision support system. IT innovations and effective intraorganizational communications go hand in hand. The larger the cultural gap within an organization, the more important is effective communication to bridge that gap.

I sat there shaking my head, then opened my laptop and recorded the following three principles:

- Metrics used to evaluate performance in the old economy may not be useful for evaluating performance in the new economy.
- Managerial performance and financial performance are not always measured on the same time scale.
- The bigger the cultural gap within an organization, the more important it is that communication bridge that gap.

**Literature Cited**


---

*John E. Lundquist (jlundquist@fs.fed.us)* is research plant pathologist, USDA Forest Service, Rocky Mountain Research Station, 240 West Prospect, Fort Collins, CO 80526-2098.